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THE ESSENTIALS OF HEMATOLOGY.

A PRACTICAL GUIDE TO THE CLINICAL EXAMINATION OF
THE BLOOD FOR DIAGNOSTIC PURPOSES.

Illustrated.

Published by
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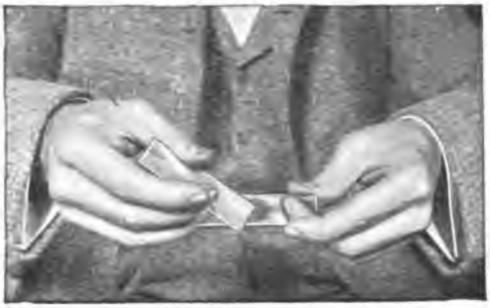


FIG. 1.
Manner of making a Smear.

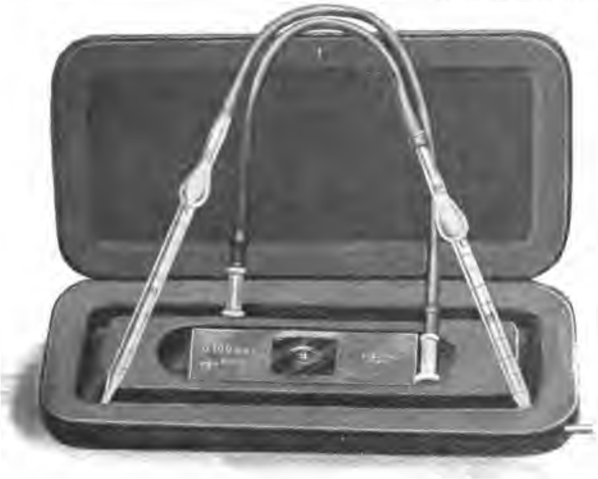


FIG. 2.
Thoma-Zeiss apparatus for counting Blood Cells.

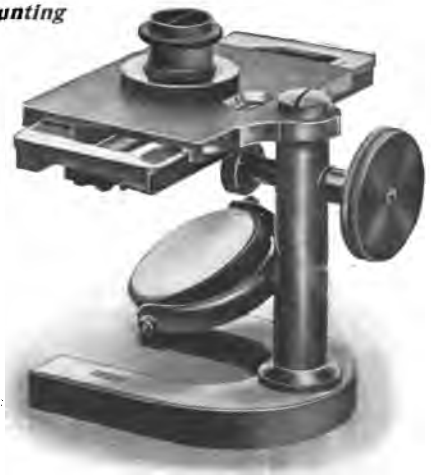


FIG. 3.
v. Fleischl's Hemometer (Hemoglobinometer).

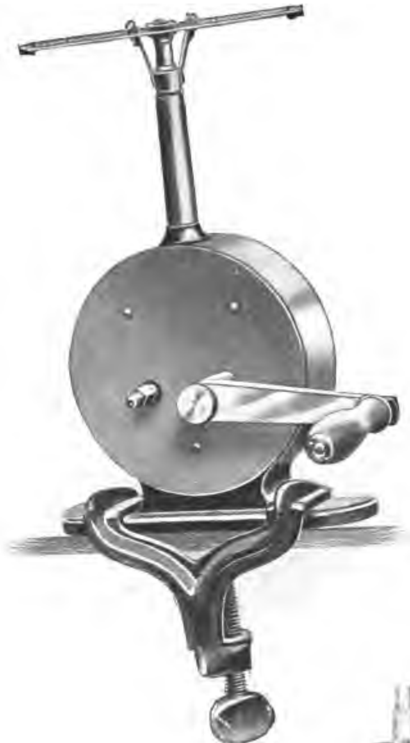


FIG. 4.
Hematocrit.

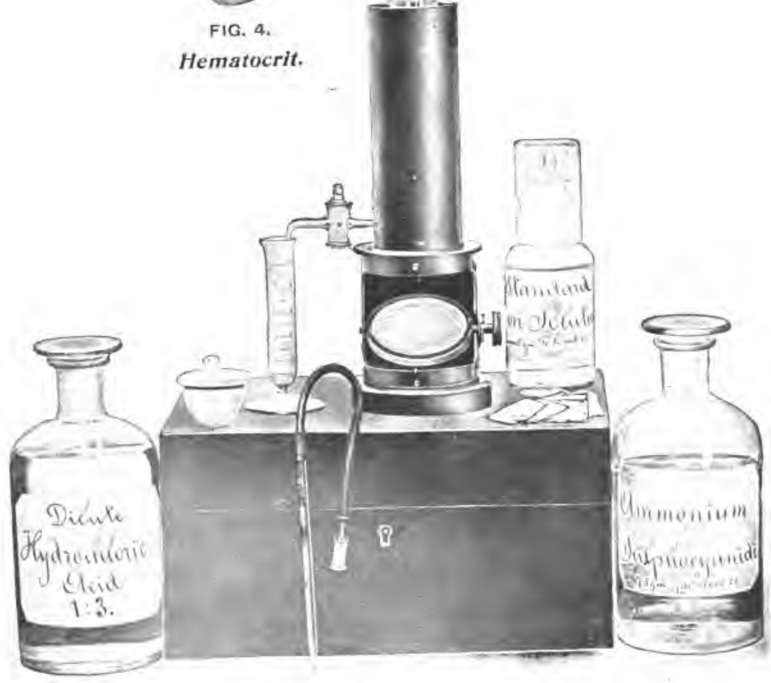


FIG. 5. ***Jolles' Ferrometer.***

which to compare the solution of blood, (3) a stand with rack and pinion, (4) a capillary tube for measuring the quantity of blood required.

1. The cell is a cylindrical metallic chamber divided by a fixed partition into two equal compartments, open at the top, and closed at the bottom by a base of glass. One of these compartments is to be filled with distilled water, the other with the proper quantity of blood dissolved in distilled water.

2. The colored glass wedge is fitted to a metal frame so that it can be adjusted in the stand and moved from side to side by the rack and pinion. When in position the glass wedge moves directly beneath that compartment of the cell which contains the distilled water, thus enabling one to compare the color of the glass with that of the dissolved blood which fills the adjoining compartments of the cell. The glass wedge is graduated from 1 to 100, the figures representing the percentage of hemoglobin in the specimen of blood as compared to normal blood containing 13.7 per cent. hemoglobin. Example $100 : 13.7 = p : x$, where p represents the reading on the scale and x the corresponding amount of hemoglobin.

3. The stand is best described by the engraving. Besides the support for the glass wedge and frame, it has a white plaster mirror, which furnishes the diffused light required in the test.

4. The capillary tubes are mounted in metal handles, and are carefully prepared to hold the proper quantity of blood. The size of these tubes varies, and on the handle of each is stamped a number indicating its capacity. Each tube must be used only with an instrument on the stand of which the same number is stamped.

Method of Use.

The capillary tube is cleaned and dried and both compartments of the cylindrical chamber three-fourths filled with distilled water. The puncture having been made as described and a small drop of blood having appeared, one end of the capillary tube is applied to the apex of the drop (not immersed in it), whereupon the tube, if in proper condition, will instantly fill with blood.

Any blood clinging to the sides of the tube must be removed, and the tube may be regarded as successfully filled when the ends of the column of blood are neither concave nor convex. This measured quantity of blood is then dissolved in one chamber of the cylindrical vessel by plunging the tube into the water, moving it back and forth in the direction of its long axis, and finally rinsing with a few drops of water. A medicine dropper with a fine point is then used for completing the filling, but no further stirring is permissible owing to the danger of overflow. By getting the eye in line with the reflection from the surface of the fluid, the filling can be done perfectly. The other compartment having been leveled up in the same way, the two looked at from above will present perfect semi-circles of equal area. The vessel should be in position on the stand, with the wedge in place, before completing the filling, since a slight shaking of the full vessel may throw some of the blood solution into the water compartment and spoil the experiment. The color of the glass wedge is designed for use with yellow light. Some, therefore, suppose an absolute dark room to be necessary for the use of this instrument. This would be unfortunate if true, for it would greatly restrict its use. As a matter of fact, if the candle flame is large, and is brought within six inches of the reflector, a moderately subdued daylight will not interfere. In strong daylight, a candle flame will not be able to correct the pinkish color which the glass wedge presents in a white light. In reading the percentage, use a tube 8 to 10 ins. long and 1½ ins. in diameter, made of any suitable material and preferably blackened on the inside. Place this on the stand surrounding the vessel, thus cutting off overhead light. Set the stand so that the partition of the vessel is in line with the vertical axis of the eye, and adjust the candle and reflector to give the best possible light. Closing the eye on the side toward the candle, apply the other to the tube, and turn the screw quickly until you find a point where the color of the two compartments appears the same. Rest the eye for a few seconds and look again. You will probably find that the color differs in the two compartments. Approximate the color as nearly as possible, and again rest the eye. Repeat until, to the rested eye, the colors are identical. Then read off the percentage. There is a reason for every detail of this process. If the partition is placed transversely, you will never be able to make a correct reading, since the upper and lower halves of the eye differ in sensitiveness to light. The adjustment of the candle must be the result of experiment, since the size of the flame often varies and since weak solutions of hemoglobin require less light than strong ones, and too strong a light makes the eye less sensitive to color gradations. The eye farthest from the flame should be used in order that the bridge of the nose may cut off any candle light from the surface of the cornea, and the same eye should always be used, because the two eyes almost invariably differ in sensitiveness to light and color; and by using alternate eyes in successive examinations you lay yourself open to error. The frequent resting of the eyes is necessary, because their sensitiveness to fine differences in tint very quickly becomes blunted, and some of the color of the part of the wedge that is moved past, seems to stick upon the retina. The ideal method of resting the eye would, of course, be to look at the complementary color: for example, a sheet of green paper, or the lining of the cover of the box in which the instrument comes. If you will observe all the precautions stated, you will be able to make very close readings with very little practice. The caution against having the capillary tube over or under-filled, and leaving blood adherent to the outside, is worth repeating, as this is a source of grave error. Inasmuch as high percentages of hemoglobin are more easily read than low ones, in cases where a low percentage is known to exist it is well to take twice or thrice the usual amount of blood, using a dry tube each time, and figuring the percentage accordingly.

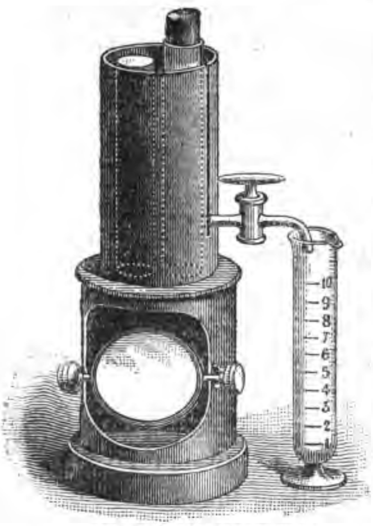
The Method of Estimating the Iron.

Jolles' Ferrometer.

As the quantity of iron in the blood of healthy individuals varies, according to Jolles, between 0.0413 and 0.0559 per cent. by weight, and as the iron varies considerably under abnormal conditions, it is of the greatest clinical importance to have a ready method for the determination of the iron in a small quantity of blood.

The accompanying apparatus (see Fig. 5, page 8) and colorimetric method meets this need very satisfactorily.

Five hundredths (0.05) cubic centimeter of blood is removed from the ear or finger, under proper precautions, by means of a capillary pipette. This is transferred entire to a perfectly clean platinum or porcelain dish and carefully incinerated over a Bunsen or alcohol flame. The blood liquid is first evaporated on a water bath to apparent dryness, and then incinerated, care being exercised to exclude dust or iron particles from the dish. The stain of red iron oxide is now treated with 0.1 gm. pure potassium bisulphate (proper quantity done up in parchment paper accompanies the instrument), and heated until no more white fumes of sulphuric anhydride arise from the dish. The dish is now allowed to cool on a glass or asbestos plate, and the contents treated with about 5 c. c. distilled water and warmed gently over flame until completely dissolved, and are then transferred to cylinder C and the dish washed with small quantities of water until it marks 10 c. c. on the cylinder. In order to have the narrow cylinder stand outside of the colorimeter, the apparatus is provided with a small support for the two cylinders.



JOLLES' FERROMETER.

The iron is determined as follows: One (1) cubic centimeter of the standard solution of iron (containing 0.00005 gm. iron per cubic centimeter) is measured by means of a proper pipette and placed in cylinder C^1, and distilled water added up to 10 c. c. Both cylinders (C and C^1) are placed side by side in the stand, and when at the same temperature 1 c. c. dilute hydrochloric acid (1 : 3) is added to each. Then add 4 c. c. of a solution of ammonium sulphocyanide (7.5 gms. per liter) to cylinder C^1 and about 3.5 c. c. to cylinder C, shaking both and covering the ends with a little glass plate, which accompanies the apparatus. Cylinder C is then filled up with sulphocyanide solution by means of the pipette, until it has a convex surface above the end of the cylinder, and then covered carefully with the polished glass plate and fastened by a metal ring. Care should be taken that no air bubble exists under the glass plate. The cylinder is now shaken again and placed in one side of the colorimeter. The small aluminum float with glass ends is now carefully adjusted on the surface of the liquid in cylinder C^1, care being taken that it floats freely and that no air bubbles exist. This is also placed in the colorimeter, and the graduated vessel A placed beneath the stopcock. It will be found when the daylight is reflected up through both cylinders that they have different intensities of red color. The liquid is allowed to flow from C^1 into the graduated vessel on the side until it has exactly the same depth of color as the contents of cylinder C. When this comparison is obtained, remove cylinder C^1 from colorimeter and read off the position of the float, taking the figure on the cylinder corresponding to the mark on the float. On referring the number of cubic centimeters found to a table, which accompanies the standard solution of iron, the percentage by weight of iron in the blood is obtained. The comparison should be made in daylight, and not with artificial light.

The Method of Counting Blood Cells.

Thoma-Zeiss Apparatus.

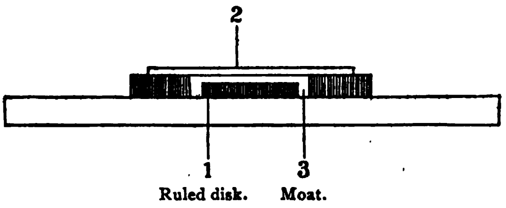
The parts of this instrument are shown in Fig. 2, page 7.

They comprise, first, a capillary tube, for measuring and diluting the blood, to which is attached a rubber tube for aspirating the blood and diluting fluid into the bulbed chamber. These tubes do not measure a fixed quantity of blood, but are graduated in three main divisions, with some finer subdivisions. When the tube is filled with blood up to the mark 0.5, and then diluted with a suitable fluid up to the mark 101, the blood is diluted to the proportion of 1 to 200. When the tube is filled with blood up to the mark 1, the subsequent dilution will be in the proportion of 1 to 100. The former dilution is the most convenient.

In the bulbous enlargement of the tube is a movable glass ball which, when the instrument is agitated, thoroughly mixes the blood and the diluting fluid.

The second portion of the instrument, known as the *counting chamber*, is constructed so as to enable one to count under the microscope all the cells in a known bulk of the diluted blood. (See cut below.)

In the center of a thick glass slide is cemented a cover-glass of accurately measured thickness with a hole in the center about 1 cm. in diameter. In the central area of this cover-glass is also cemented to the glass slide a glass disk about 2 mm. smaller in diameter and exactly $\frac{1}{10}$ mm. thinner than the cover-glass. The glass shelf being exactly $\frac{1}{10}$ mm. thinner than the cover-glass, it will readily be seen that if a second loose cover-glass is laid upon the first, the under surface of this loose cover-glass will lie exactly $\frac{1}{10}$ mm. above the upper surface of the glass disk. In this way is secured a layer of fluid $\frac{1}{10}$ mm. in depth. Furthermore 1 sq. mm. of the



THOMA-ZEISS COUNTING SLIDE.

surface of the disk is outlined and subdivided by intersecting lines into 400 small squares. For convenience in counting, every fifth row of squares is divided into two by an additional line.

If now you count the cells seen in one of these small squares you will have counted all the cells present in $\frac{1}{4000}$ of a cubic millimeter of diluted blood, because the layer of diluted blood is $\frac{1}{10}$ mm. thick, and the area of the small square is $\frac{1}{400}$ of a square millimeter.

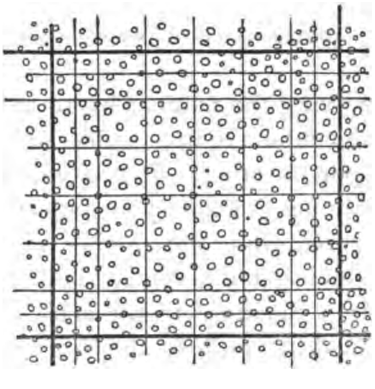
The best dilution fluid is Hayem's, which is made up as follows: —

Bichloride of mercury	0.5 gms.
Chloride of sodium	1.0 ,,
Sulphate of sodium	5.0 ,,
Distilled water	200.0 c. c.

A 3 per cent. salt solution answers the purpose, but does not keep well.

Counting the Red Cells.

In enumerating the red cells, the entire procedure is as follows: With your bottle of dilution fluid uncorked and close at hand, and having assured yourself that the capillary tube or mixer is thoroughly clean and dry, puncture the ear lobe in the manner described, and immersing the tip of the tube in the extruded drop, suck up blood to the mark 0.5 or a little more. Quickly wiping away the blood clinging to the tip of the tube, and accurately noting the point to which the column of blood reaches, plunge the tube into the dilution fluid, and instantly begin to suck away, rolling the tube between the thumb and fingers in order that the blood and fluid may be as thoroughly mixed as possible before the bulb is completely filled. Without this precaution, some of the blood will float up on the surface of the fluid and pass out of the bulb. As the tube becomes nearly full, stop sucking, and begin again very gently, or you will not be able to stop at the 101 mark, and your specimen will be over-diluted. Having successfully filled the tube, close its ends with thumb and forefinger, and catching the dangling rubber tube between the other fingers, shake the whole thing vigorously. If you pull off the rubber tube before shaking the mixer, you will probably create a vacuum which will pull some of the fluid out of the bulb. A minute's vigorous shaking is sufficient. Now with water and a towel carefully clean and polish the loose cover-glass and the counting chamber with its surrounding shelf. Then with a final shaking of the mixer, depending in amount upon the time that has intervened since the original one, blow out three drops, wipe the end of the tube, and gently blow out another very small drop and deposit it upon the center of the counting disk. The size of this drop can only be learned by trial, but it must be of just such size that when you have gently let down the cover-glass upon it, it will exactly cover the entire disk, without running over into the moat. In this case, if the cover-glass and the surrounding shelf are perfectly clean, there will appear at some point between the two surfaces of glass the rainbow of colored Newton's rings. Sometimes a gentle pressure upon the cover-glass is necessary to bring them out. A firm pressure will produce them, whether the disk be incompletely covered or whether the fluid is spilled over into the moat around it, but they will disappear as soon as the pressure is removed. A test of the accuracy of your work, then, lies in the permanency of these color rings. At each unsuccessful attempt, you must again clean the slide and cover-glass, shake the mixer, and throw a drop away. Having accomplished the purpose in hand, put the slide on the stage of the microscope with numerals to the left, and steady that end with a clip. Using a No. 7 ($\frac{1}{8}$ in.) objective, and a No. 3 ($1\frac{1}{2}$ in.) eye-piece, and a diaphragm of small aperture, locate the upper left-hand corner of the checkered space. This corner will look like cut.

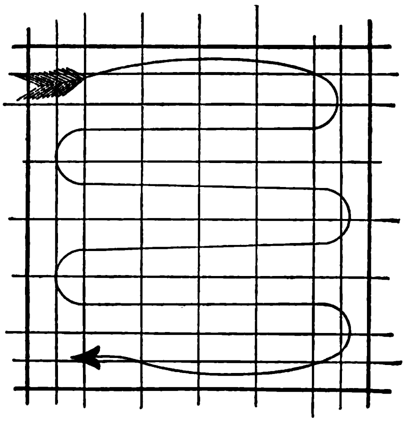


FIELD OF 36 SQUARES ON THOMA-ZEISS COUNTER.

Beginning at the left of the first oblong of 5 squares, include in your count not only those cells lying completely within the space, but also every cell that barely touches it on the left end and lower side. Those cells that touch the upper border or right end, even if they lie within the space itself, must not be included.

Having completed the count from left to right, drop down to the next lower oblong and count from right to left. If you have been careful to include in the count of the next oblong above all those cells touching its lower border, you will avoid counting the same cell twice.

Proceeding in this manner alternately from left to right and from right to left, continue counting until you have passed through the entire column of 100 squares consisting of 20 oblongs of 5 squares each. For greater convenience, set down the number in each 25 squares as you complete them. Count the three other columns in the same way. A total count for the 400 squares will represent the number of cells in a layer of fluid containing $\frac{1}{10}$ of a cubic millimeter. Since the total area of the 400 squares is 1 sq. millimeter and the depth of the layer is $\frac{1}{10}$ of a millimeter, multiplying the number by 10 will give you the number which would be contained in a cubic millimeter, or 10 such layers piled one upon the other. If now you multiply this number by the amount of dilution to which you subjected the blood, you will have the figure representing the number of cells in a cubic millimeter of blood, which is the accepted standard of measure. If, for example, you drew blood up to the mark 1, you diluted it 100 times when you filled the bulb to the 101 mark. The tube below the mark 1 is subdivided into tenths, and you will ascertain your degree of solution by dividing 1 by the fraction representing the height of the column of blood and multiplying by 100. It is neither easy nor necessary in drawing up the sample of blood to stop at a particular mark, provided it is between 0.5 and 1. The nearer to mark



ORDER OF COUNTING SQUARES.

1 you go, the more corpuscles you will have to count, and this extra labor is unnecessary. If the column reaches a point between the subdivisions, you can readily read off the fractional part of the subdivision in tenths and allow for it in your estimation. If, for example, the point was 0.5 plus $\frac{4}{10}$, or 0.54, your dilution found by dividing 1 by .54 will be 185 +. If, however, you attempt to fill the tube to mark 1, you will very likely run by it; then you have no recourse but to clean your tube and start over again. You should be careful to clean and dry the tube as soon as you are done, in the following manner; having expelled the remaining fluid, fill the bulb repeatedly with water, shaking it each time before expelling; then with a mixture of alcohol and ether, give the mixer a final rinsing and suck air through the tube until it is dry, agitating the glass ball the while. If you put off cleaning the tube too long, you will find it well-nigh impossible to free it from the serum which will stick to it. You will find no necessity for using a stain in your dilution fluid, as many recommend, in order to exclude the leucocytes in your counting, since the grayish, granular, glistering appearance of the leucocytes is too characteristic to be mistaken, and you will be saved the increased labor of cleaning the pipette which the use of a staining fluid would inevitably involve.

Counting the White Cells.

The white cells are best counted in the special mixer giving a 1 to 10 dilution, which accompanies the complete Thoma-Zeiss apparatus. The methods of procedure are, in general, the same as in the case of the red cells, though you must have a more abundant flow of blood in order to fill the tube, because it has a much larger calibre. For the same reason you must be very careful in inserting the tube into and withdrawing it from the dilution fluid, for its contents rapidly run out when it is tilted. For the dilution fluid in this instance you should use a ⅓ of 1 per cent. solution of acetic acid. This will dissolve the red cells and swell up the white ones, rendering their nuclei more prominent, so prominent in fact that here also the staining fluid is wholly unnecessary. You will find it much quicker work counting the whites than the reds, owing to their relatively small number, and owing to this fact also it is well to count the 400 squares in two or three specimens and strike an average before estimating them. In counting, start at the same corner as before, but instead of taking the sinuous path through the oblongs of 5 squares, take two or three columns of small squares at a time and sweep through them from top to bottom and from bottom to top, alternately. Make the estimation of the number of leucocytes in a cubic millimeter in the same way as for the red cells, remembering, however, that the dilution is 1 to 10 instead of 1 to 100, when the column of blood is drawn up to mark 1. Thus, if the column of blood has reached the mark .6, the dilution will be 1 divided by .6, or 1⅔ multiplied by 10, or 16⅔. If, for example, you have found the average number in 400 squares, or 1 sq. mm., to be 48, then the number in a layer $\frac{1}{10}$ of a millimeter deep and 1 mm. square will be 48 × 16⅔, or 700, so that the number in 10 layers, or 1 c. mm., will be 10 times 700, or 7,000.

The Preparation of Dried Specimens of Blood.

Very complete information as to the changes in the blood in disease may be obtained from the examination of dried specimens, which, therefore, constitute the most important feature of blood analysis.

The first part of the process is the preparation of glass slides on which to spread the blood. The ordinary commercial slides must be thoroughly cleaned with soap and water and polished with a clean, dry towel. They must be absolutely free from dust, and should be polished immediately before using.

Draw a drop of blood from the ear lobe in the usual manner and transfer it to the center of the clean slide by touching the slide to the apex of the drop. Then drag the clean end of the second slide along the surface of the first at an acute angle to it (see Fig. 1, page 7), until the drop is reached and included in the apex of the acute angle. Pause a moment for the drop to run along the edge of the slide, then continue to drag the slide along in the same direction with a gentle, steady pressure, smearing the blood over the first slide in a thin, even layer. A little practice will enable you to make excellent smears in this way. The slide used to smear with may be used to receive the next drop, a third being taken with which to do the smearing, and so on. Upon the success of this procedure will depend much of the value of your examination, and it is well to be prepared to take at least half a dozen specimens at first, so that at least one or two will be available. The smears will dry almost instantly in the air, and in this condition will keep for some time.

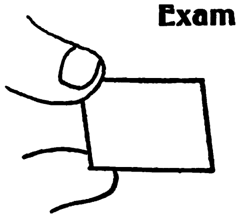
The next step in the treatment of the slide is the hardening process. Into a broad, shallow dish with about a quart capacity, having a practically air-tight cover, pour a few drops of 40 per cent. formalin and arrange the slides in it upon some sort of support that will keep them from contact with the liquid. Strips of tin or zinc may be bent to form shelves for this purpose. Adjust the cover and allow the slides to remain in the formalin vapor for fifteen or twenty minutes. Then remove them and after a two or three minutes' exposure in the air they are ready to stain. The staining fluids that will give you the most satisfaction are properly prepared solutions of eosin and methylene blue.

It is well to make stock solutions of these dyes from which fresh staining solutions may be quickly prepared as needed. These stock solutions are prepared in the following way: Put enough dry eosin into a bottle of pure methyl alcohol to leave a sediment after the bottle has been shaken and left to stand for some hours. From this stock solution you may at any time prepare your staining fluid by drawing off some of the supernatant fluid with a pipette and mixing it with twice its volume of water. A saturated solution of methylene blue is made with water in the same way, and of this stock solution one part in twenty of water will give the proper strength for your purpose. The weaker solution of methylene blue soon deteriorates and must be replaced by a fresh solution every two or three weeks.

The dry stains made by the different chemists vary greatly in coloring properties. The regular commercial eosin and medicinal methylene blue sold by Merck usually give excellent results. Grübler's dyes are those generally recommended. The so-called alcoholic eosin is the one to be selected in any case. Stand up the slides in a beaker with the smeared surfaces free from contact and pour in eosin solution to a level above the smears. Leave the smears in the solution for ten minutes, then wash off the eosin with a gentle stream of water and plunge at once into a beaker of methylene blue solution. Leave them here from one to three minutes, according to the age of the solution, fresh solutions staining most quickly. Then wash and dry with soft filter paper. If the washing is done with undistilled water, it must be done very briefly, as ordinary water more quickly dissolves out the stain. The dried specimen is ready for examination with the oil-immersion lens, a drop of oil being put directly on the slide, although, if preferred, a cover-glass may be cemented to the slide by a drop of Canada balsam, to guard against any possible injury to the smear in future manipulations.

The only other staining solution in general use is the Ehrlich tri-acid stain. If you wish to use it, you should buy it ready made by Grübler, for its preparation involves a great deal of trouble and several weeks' time. Flood the hardened smear with the stain, leaving it on one minute. Wash off quickly and as quickly dry with filter paper, for water very rapidly dissolves out one of the ingredients of the dye. This stain was originally designed for the demonstration of the neutrophile granules, but in other respects it has little or no advantage over eosin and methylene blue. When used as described above it finds its best use in staining leukemic blood. To obtain the best results with this stain, fix the specimens by heat in an oven designed for the purpose; run up the heat quickly to 150° C. and remove them as soon as this point is reached. Better results are thus obtained than by longer exposure to 110 or 120°, as generally recommended.

Examination of Fresh Specimens.



METHOD OF HOLDING COVER-GLASS.

For this purpose you need, in addition to the slides, cover-glasses. Both should be thoroughly cleaned and polished. Holding a cover-glass as shown in the cut, catch a minute drop of blood upon its center and drop the cover-glass face down upon the slide. The blood will spread between the two surfaces of glass in a thin, even layer if both are perfectly clean. Thick layers caused by imperfect spreading, or by too large a drop, are of no use, for the red cells overlie each other, or form *rouleaux*. If the slide is slightly warm before putting the cover-glass upon it, the blood will spread better. Examine by means of a $\frac{1}{12}$ oil-immersion lens with subdued light. Much can be learned from these specimens, *e. g.*, leucocytosis, marked deficiency in hemoglobin, as shown by the pallor of the red cells and the increase in the size of their central clear area, variations in shape and size, and the presence of parasites. This is the ideal method of examining the blood for the malarial plasmodium.

The Normal Histology of the Blood.

A brief description of the normal histology of the blood is necessary before proceeding to the changes occurring in disease.

The *red blood cells* are bi-concave, disk-shaped bodies; composed largely of a semi-fluid, iron-holding albumen called hemoglobin, surrounded by a delicate, invisible membrane, and capable of a variety of physiological changes in shape. Their numbers vary between 4,500,000 and 5,500,000, being usually above 5,000,000 in the healthy male subject, and below that number in the female. In shed blood, viewed under the microscope, they have a greenish-yellow tint, a thick, opaque border, and thin, translucent center, and show a very distinct tendency to form *rouleaux* (Plate I., Fig. 1). In dry specimens stained by eosin or the tri-acid mixture, the normal red cells, when thickly spread, exhibit an opaque, reddish border, gradually shading off toward the center of the cell, which is quite transparent. This transparent center is a normal character of the cell and should not be mistaken for a deficiency of hemoglobin. When thinly spread and rapidly dried, the normal red cells are stained diffusely, and fail to show the transparent central area, even when markedly deficient in hemoglobin (Plate I., Fig. 1). The hemoglobin of the red cells is markedly *acidophile* in its staining tendency, uniting only with the acid stain (eosin, fuchsin) when treated by mixtures containing both acid and basic dyes.

When blood is smeared on a slide and stained by eosin and methylene blue, some red cells are usually crushed, and their extruded contents take a bluish stain and are identical in appearance with the so-called "blood plates" (Plate I., Fig. 1).

The red cells are derived from nucleated red cells of slightly larger size (normoblasts) which, after birth or infancy, are found exclusively in the bone marrow. The presence of nucleated red cells in the circulation is always pathological, except in the blood of new-born infants, in which a prolonged search will usually disclose the presence of one or more normoblasts (Plate I., Fig. 4).

The *white blood cells or leucocytes* are *colorless*, highly refractive, spheroidal bodies, 5 to 15 micro-mm. in diameter, occurring in normal blood in the proportion of 6 to 10,000 per cubic millimeter. They invariably contain a nucleus surrounded by more or less demonstrable protoplasm, and upon the characters of the nucleus and cell body, as demonstrated by certain dyes, the classification of leucocytes is based.

When specimens of dried blood are stained by eosin and methylene blue (Plate II., Fig. 10), many of the leucocytes are found to stain diffusely blue, both nucleus and cell body taking up methylene blue in preference to eosin. Methylene blue being a basic dye, those leucocytes whose bodies stain blue are called *basophile* cells. The basophile cells of normal blood are supposed to be derived exclusively from the lymphoid structures of the body and are therefore also called *lymphocytes*. The lymphocytes vary much in size; some, called the *small lymphocytes*, are composed almost wholly of the nucleus surrounded by a little protoplasm, in which fine basophile granules may usually be detected (Plate I., Fig. 3).

Others, the *large lymphocytes*, have an abundance of protoplasm in which no granules are ordinarily seen (Plate I., Fig. 3). The nucleus of the lymphocyte is usually spherical, but may be horseshoe shaped, in which case the term *transitional leucocyte* was once applied to the cell. (See Plate I., Fig. 1.) When lymphocytes are stained by the tri-acid mixture the nuclei are rather faintly stained blue, while the bodies are quite homogeneous and of a slightly reddish tinge.

By the same treatment with eosin and methylene blue, other larger and more numerous leucocytes are seen to contain nuclei, more or less completely subdivided into two or more lobes, usually connected by a delicate thread and surrounded by considerable hyaline, slightly reddish-stained protoplasm, thickly studded with fine red granules (Plate I., Fig. 2).

These granules have received the term *neutrophile*, and the leucocytes containing them are called the *polynuclear neutrophile leucocytes*.

Finally, in specimens stained by eosin and methylene blue a few leucocytes will usually be found containing a single or bi-lobed nucleus surrounded by protoplasm, in which there are many large granules staining bright red with the eosin.

On account of the marked affinity of these large granules for eosin, these cells are called the *eosinophile leucocytes* (Plate I., Fig. 1).

The tri-acid mixture which stains the neutrophile granules a dark red also stains the eosinophile granules, which are to be distinguished from the neutrophile granules only by their greater size (Plate I., Fig. 2).

The above forms of leucocytes are found in normal blood in the following proportions: —

Small lymphocytes	20 to 30	per cent.
Large lymphocytes	4 to 8	,,
Polynuclear neutrophile leucocytes . .	62 to 70	,,
Eosinophile leucocytes	1 to 4	,,

In the blood of healthy infants the proportion of lymphocytes may be considerably increased.

Anemia.

Anemia is a term applied to a pathological condition of the blood, characterized by a diminution in the number of, and a decrease in the hemoglobin percentage of the red cells, by certain changes in the shape and size of these cells, and by a loss of albuminous and other constituents of the plasma. The anemia may be of moderate severity and be termed *simple* anemia, while most of the grave forms of the malady, tending to a fatal issue, are usually called *pernicious* anemia. The condition of the blood may appear to result largely or exclusively from abnormalities in the blood-producing functions, in which case the disease is classed as *primary* anemia, or it may result from the actual loss of blood by hemorrhage, or from some general infectious disease, or chronic toxemia, when it is properly classed as *secondary* anemia.

Chlorosis.

Chlorosis is a simple primary anemia, principally affecting young women, but seen occasionally in young male subjects. In the mildest form of the disease there is a diminution in the quantity of hemoglobin in the red cells, and probably also of albumens in the plasma, but without any marked reduction in the number of red cells. In such cases the hemoglobin registers from 25 to 60 degs., and the red cells about 4,000,000 or more to the cubic millimeter. The character of the blood in this condition appears very distinctly in dried specimens stained by eosin and methylene blue (Plate I., Fig. 3). Here the red cells show a uniform reduction of the amount of hemoglobin, and the stained portion of the cells is limited to a rather narrow peripheral ring, while the central clear area is correspondingly widened. In early stages of the disease but little change in the shape and size of the cells is noticed, but as the disease increases in severity, though their number, as a rule, remains nearly normal, they begin to suffer marked alterations in shape and size. In such cases the hemoglobin may register as low as 20 per cent., while the number of red cells may be 4,000,000. Cases of long standing, however, occur in which the number of red cells is not more than half the above. In stained specimens the red cells, being very deficient in hemoglobin, appear as narrow rings with very wide central clear areas. The changes in shape and size of the cells are apparent in the presence of a few cells which are distinctly larger than normal, though the majority are smaller than normal and show marked irregularities in shape. In severe cases of chlorosis nucleated red cells of normal dimensions are often encountered, especially when the patient is improving. In chlorosis all forms of leucocytes may be slightly increased in number, and this leucocytosis is usually associated with the appearance of nucleated red cells in the blood. The improvement of the patient suffering from chlorosis may be accurately followed by actual estimation of hemoglobin, and enumeration of the red cells, and also in stained specimens by noting the increasing thickness of the ring of hemoglobin in the red cells.

In mild cases improvement follows rapidly from rest in bed and proper medication. In severe cases improvement is more difficult to secure, many cases being refractory to most therapeutic measures, and requiring very energetic treatment with active preparations of iron.

Most cases eventually recover under such treatment; some are prone to relapse when the treatment is suspended; while others, under unfavorable conditions, may develop pernicious anemia.

Pernicious Anemia.

Pernicious anemia, strictly speaking, is a primary disease of the blood, or blood-producing organs, attended with great reduction in the number of red cells, with peculiar changes in their shape and size, with marked diminution in the total quantity of hemoglobin in the blood and of albumens in the plasma, and tending to a fatal issue.

The steps in the process leading to these serious changes in the blood are not definitely understood, but the condition appears to result from both defective formation and excessive destruction of the blood.

A good many cases, clinically regarded as primary pernicious anemia, are found on autopsy to be referable to such conditions as chronic gastritis, cancer of the stomach, chronic nephritis, intestinal parasites, repeated small hemorrhages, etc. But apart from these cases there appears to be no doubt that there are cases of pernicious anemia, often rapidly fatal, in which no adequate cause, or even predisposing condition can be found at autopsy, and it is to these cases that the term *primary pernicious anemia* should be restricted.

The chief lesion in the blood in primary pernicious anemia is an extreme reduction in the number of red cells, which are nearly always less than 2,000,000, often less than 1,000,000, per cubic millimeter.

The hemoglobin is greatly reduced in quantity, usually measuring from 10 to 30 per cent., but it is characteristic of primary pernicious anemia that the hemoglobin is not reduced in the same proportion as in chlorosis, and cases are occasionally seen with a hemoglobin percentage of 60 to 70, in which the blood presents all the characteristics of a pernicious anemia.

This is explained by the fact that the remaining cells in pernicious anemia are rich in hemoglobin, while in chlorosis all the red cells are markedly deficient in this constituent.

The red cells in pernicious anemia exhibit striking peculiarities. They vary greatly in size, a considerable proportion being very large, 10 to 15 micro-mm. in diameter, and are called *megalocytes* (Plate II., Fig. 5). On the other hand, a considerable number of red cells are extremely minute — *microcytes* (Plate II., Fig. 5). *Poikilocytosis*, that is, marked variation in the shape of the red cells, is also a constant characteristic.

A valuable diagnostic feature apparent in stained specimens is the nearly uniform increase of hemoglobin in the red cells, which usually stain uniformly deep red (Plate II., Fig. 5). This serves at once to distinguish the disease from most other forms of anemia. There are also certain degenerative changes in the red cells which occur almost exclusively in pernicious anemia. In normal blood the red cell stains with eosin a uniform bright reddish color. In pernicious anemia the hemoglobin often undergoes a change, possibly with the formation of methemoglobin, which causes the cell to stain dark brown with eosin instead of red. This variability in the staining reaction of the red cells is called *polychromatophilia*.

The red cells of pernicious anemia lose most of their cohesive quality and fail to form *roulcaux*, being usually found singly throughout the specimen, even when present in considerable numbers.

Probably the most characteristic feature of the blood of primary pernicious anemia is the presence, often in considerable numbers, of nucleated red cells of excessive size—*megaloblasts*. These cells are derived from the bone marrow, and their appearance in the blood indicates a serious change in this blood-producing organ. They are regarded as a pathognomonic sign of primary pernicious anemia. They may contain a single rounded nucleus, or the nucleus may be variously subdivided, being often of a rosette shape. They usually contain an excess of hemoglobin, staining bright red, or brownish, or exhibiting a number of fine bluish staining points, probably derived from a disintegrating nucleus (Plate II., Fig. 5).

Besides the megaloblasts, some nucleated red cells of small size may occasionally be seen. These are called *microblasts* (Plate II., Fig. 6).

In rapid cases of pernicious anemia it is not uncommon to find nucleated red cells in the process of indirect division or mitosis. They may be found in the early thread stage (Plate II., Fig. 6) or in the aster stage (Plate II., Fig. 6). In the latter case it is often evident that the mitotic process is abnormal, in that three or more asters are produced instead of two, and that these subdivisions are unequal. Such nucleated cells with dividing nuclei are found only in primary pernicious anemia.

In some nucleated cells of pernicious anemia, the nucleus appears projecting prominently from the edge of the cell, as though about to be extruded. It is believed by many that this is the natural method by which the newly formed red cell loses its original nucleus (Plate II., Fig. 6).

The leucocytes of primary pernicious anemia are usually diminished in number, and those remaining are mostly of the mononuclear type. This character may serve to distinguish the primary disease from other forms of severe secondary anemia depending upon some lesion which causes an increase of leucocytes.

Primary pernicious anemia is usually a fatal disease, being quite refractory to ordinary treatment with iron and to most other therapeutic measures. Very rapid cases are entirely unaffected by treatment, but the more prolonged forms of the disease may be considerably improved by active medication.

It is probable that some cases recover.

Secondary Anemia.

The primary anemias are rare in comparison with the great number of cases of secondary anemia encountered in general practice; for nearly every disease that interferes with the normal nutrition of the patient leads to more or less impoverishment of the blood, causing a variety of anemia spoken of as *secondary*, because it is only one of a number of symptoms of the original disease. The changes in the blood in secondary anemia may resemble those of chlorosis, or in more severe cases may resemble those of pernicious anemia, and we speak therefore of *secondary chlorotic anemia* and of *secondary pernicious anemia*.

Secondary chlorotic anemia is the most common of all diseased conditions of the blood. Not only does it follow, in some degree, all acute and chronic infectious processes, but a great variety of simple functional disturbances, especially if long continued, lead to an anemic condition. The exanthemata are common causes of secondary anemia in children, usually of a mild type, while tuberculosis and rachitis are responsible for many cases, usually of a pronounced type, of secondary chlorotic anemia, occurring in early life. In adult life, tuberculosis, syphilis, malaria, nephritis, chronic gastritis, and malignant neoplasms are usually associated with considerable anemia, generally of the chlorotic type.

At any age the system may be rapidly drained of the formed and fluid elements of the blood by hemorrhage, prolonged suppuration, or diarrheal diseases, all of which are early followed by marked anemia.

In secondary chlorotic anemia the chief lesion in the blood is, as in primary chlorosis, the loss of hemoglobin. This change may be very severe, some cases, such as result from hemorrhage, registering as low as 12 to 15 per cent., a point to which the hemoglobin rarely or never falls in simple chlorosis. In such cases also, the reduction in red cells may be very great, these numbering as low as 1,000,000 per cubic millimeter, a figure almost never seen in simple chlorosis. In spite of the severity of the anemia, the remaining cells in these cases exhibit only the changes resulting from deficiency of hemoglobin, and do not, in more than a very slight degree, show the characters of pernicious anemia.

Usually, however, secondary chlorotic anemia is of much milder grade, showing only a moderate loss of hemoglobin and reduction in red cells, and it is characteristic of these cases that the diminution in cells and loss of hemoglobin are apt to be fairly uniform. This is contrary to the rule in chlorosis, in which the loss of hemoglobin is always much greater than the loss in red cells. Thus it is not uncommon to find a case of chlorosis with 3,500,000 red cells and 25 per cent. of hemoglobin, while the parallel case of secondary anemia with 3,500,000 red cells is more likely to show 40 or 50 per cent. of hemoglobin.

Another feature which may serve to distinguish secondary chlorotic anemia from chlorosis is the fact that in many cases of the former condition the leucocytes, especially the polynuclear variety, are distinctly increased, while such an increase is rare in simple chlorosis. The increase of leucocytes in secondary anemia is referable to the primary disease.

The changes in the blood of secondary chlorotic anemia are illustrated in Plate I., Fig. 7, drawn from a case of ulcer of the stomach, suffering from severe anemia. Here the chief abnormalities are the loss of hemoglobin in otherwise normal cells, and the increase of polynuclear neutrophile leucocytes. The hemoglobin in this case registered 20 per cent. and the red cells numbered 2,100,000.

The exact characters of the blood in secondary anemia vary considerably, being determined largely by the character of the lesion in the disease producing the anemia. Thus the character of the anemia following hemorrhage is markedly different in several particulars from that associated with tuberculosis. In some cases of secondary anemia, occurring in children, there are several features which are not met with in adults, and are often so striking that some writers have been led to class these cases of anemia in children as a separate disease of the blood. In young subjects suffering from severe rachitis or tuberculosis such a form of secondary anemia occurs, and has been described under the term *anemia infantum pseudoleukemia*, or *v. Jaksch's anemia*. The blood from such a case is represented in Plate II., Fig. 8.

Here the red cells are greatly reduced in number and in hemoglobin, but do not exhibit great alteration in shape or size. Nucleated red cells are present in considerable numbers, but these are usually of normal size, as seen in chlorosis. The leucocytes are very much more numerous than is normal, in this instance numbering 92,000.

Most of these leucocytes are of the mononuclear basophile type (lymphocytes), but occasionally one meets with a mononuclear cell containing neutrophile granules, *i. e.*, a myelocyte (Plate II., Fig. 8). Myelocytes in any considerable numbers are characteristic of leukemia, but may be seen, in very small proportions, in secondary anemias.

The chief features of the blood in v. Jaksch's anemia are, therefore, the presence of many nucleated red cells, and of a greatly increased number of leucocytes, mostly of the mononuclear type. Both these features, in a lesser degree, characterize nearly all forms of secondary anemia in children, and Plate II., Fig. 8, is intended to illustrate the changes in the blood that may be expected when dealing with secondary anemia in early life.

The treatment of secondary chlorotic anemia is directed chiefly toward the primary disease, but the condition of the blood can be very favorably affected by medication with active preparations of iron.

Secondary pernicious anemias are those graver disorders of the blood which follow many of the diseases enumerated as causes of chlorotic anemia. When the diseases are very severe or long continued, many of them lead rather rapidly to profound changes in the blood, which so closely resemble the lesions of primary pernicious anemia as to be frequently mistaken for it.

For reasons not quite clear, some diseases are more apt than others to be followed by a pernicious type of anemia. Among these are especially to be mentioned hemorrhages, cancer of the stomach, chronic gastritis, syphilis, malaria, and infection by intestinal parasites.

Most cases of secondary pernicious anemia pass through a preliminary stage of chlorotic anemia, the lesions of a pernicious type supervening either gradually or, at times, quite rapidly.

When the condition is well established the changes in the blood are usually very distinct, and are illustrated in Plate II., Fig. 9, drawn from a case of cancer of the stomach, one of the most frequent causes of this type of anemia.

Here the red cells are greatly reduced in number, 1,100,000 per cubic millimeter. The hemoglobin registered 15 per cent. A prominent feature in the red cells is the extreme deficiency in hemoglobin, in which particular they differ from the cells of primary pernicious anemia. The variations in the shape and size of the cells are almost as great as in the primary disease, a characteristic apparent in most cases of secondary pernicious anemia.

Nucleated red cells, however, are not seen as a rule, and, if present, are usually of normal size. The absence of megaloblasts is therefore evidence of the secondary character of the anemia. The leucocytes, especially those of the polynuclear neutrophile variety, are, as illustrated in the drawing, nearly always increased.

Such are the features of the blood in most cases of secondary anemia of pernicious type. When, however, the disease is secondary to late syphilis or to the action of some intestinal parasites, the type of changes in the blood may closely resemble that seen in the primary form of pernicious anemia, and this fact has led some writers to claim that all varieties of pernicious anemia are essentially the same. Plate II., Fig. 10, represents the changes in the blood in a case of pernicious secondary anemia following advanced syphilis. The blood resembled in many respects that of the primary pernicious disease, but no megaloblasts were at any time seen, and many of the large megalocytes instead of showing an increase were very deficient in hemoglobin. The leucocytes also, especially the mononuclear variety, were considerably increased in number.

From the character of the blood changes in this case, which is an average instance of a considerable group, it will be seen that the separation of grave secondary anemia from primary pernicious anemia is not always easy. The points chiefly relied upon in the diagnosis of the secondary condition are: the tendency of most red cells to be deficient in hemoglobin; the absence of megaloblasts and the presence of leucocytosis.

The treatment of secondary pernicious anemia is, of course, mainly directed toward the removal of the original disease, and is often ineffectual because the lesion in the viscera is usually of a permanent character.

If the original disease can be kept in abeyance much improvement may be expected by general therapeutic measures aided by active preparations of iron. In any case recovery is slow and often interrupted by periods of relapse.

Leukemia.

Leukemia is a disease of the blood-making organs characterized by special changes in the bone marrow, spleen, and lymphatic glands, any one or two or all three, and by a leucocytosis of a peculiar type. It tends to run a chronic course, though comparatively acute cases occur at times, and is often accompanied by secondary lymphoid infiltration of various organs. The most common types are the *lymphatic*, in which the lymphatic structures are chiefly involved, and the *lieno-medullary*, in which the spleen and bone marrow are the principal seats of lesion. The blood changes are such as indicate a severe disturbance of the hematogenetic functions and differ in a marked degree in the two types. In the lieno-medullary variety the red cells show a marked diminution in number and a reduction in the amount of hemoglobin. Advanced cases usually present less than 2,000,000 red cells to the cubic millimeter, while the hemoglobin registers well under 30 per cent. There is also the wide variation in shape and size of the red cells which accompanies every severe chronic anemia. The nucleated red cells, which are usually present in considerable numbers, are nearly all of a normoblast or microblast type. The presence of the megaloblast variety, which characterizes the blood of pernicious anemia, is the exception rather than the rule. Still more marked are the changes in the leucocytes. Their number is usually enormously increased, at times reaching as high as a million, and in addition to the usual types of cells there are present in considerable numbers one and often two varieties never seen (except an occasional stray one) in any other condition. These are the so-called *markzellen*, or myelocytes, and the *mastzellen*.

The myelocytes are cells ranging in size from two to six times that of red cells, with a single pale nucleus, sometimes irregular in outline, but usually oval, lying either in the center or toward the periphery of the protoplasm, which is generally filled with neutrophile, but sometimes with eosinophile granules. As their name would indicate, they are found only in that form of the disease in which the bone marrow is involved. The mastzellen (nutritive cells), so-called from an erroneous conception of their function, are usually of the size of the small lymphocytes, though they may be larger. They contain a single deeply staining oval or rounded nucleus surrounded by a protoplasm filled with very coarse basophilic granules. They are more commonly found in the lieno-medullary type of the disease, and occur in varying numbers; in one case under observation, they outnumbered the myelocytes. An occasional cell of this type is frequently seen in other conditions.

Another type of cells sometimes seen in other impoverished conditions of the blood, but never in so great numbers as in this disease, is a very large cell, the *giant basophile*, the largest ever seen in the blood without granules and taking a basophilic stain throughout, but in such an irregular way as to give the cell a mottled, half washed-out look, the nucleus being hardly distinguishable from the surrounding protoplasm. They are ordinarily classed among the lymphocytes, though their extreme size (often twice that of the ordinary large lymphocyte) and their peculiar appearance make them worthy of separate mention. Nearly all the polymorphonuclear leucocytes occurring in leukemic blood present a marked peculiarity in the color acceptance of their nuclei, which stain in some spots very lightly, where they have a blurred, somewhat vacuolated appearance. This is probably the evidence of a retrograde change in the cell.

The blood in the lymphatic type of leukemia differs in many ways from that of the lieno-medullary. The changes in the red cells are the same as those seen in a severe chlorosis, nucleated cells being seldom seen and never in any great number. The white cells are made up almost entirely of lymphocytes, the small form predominating. At times they constitute as much as 97 per cent. of the total number of leucocytes. Myelocytes do not occur, nor as a rule do mastzellen, but the giant basophile described above is seen in limited numbers.

Malaria.

Malaria is an infectious fever, of an intermittent or remittent type, caused by the presence in the blood of a protozoön known as the *plasmodium malariæ.* The intermittent type is characterized by paroxysms of fever, between which there is a total intermission. The attack commonly begins with a chill lasting from a few minutes to an hour or two. This is followed by a fever period of from four to ten hours' duration, ending in the sweating stage, during which the temperature rapidly falls to normal. As a rule, the more frequent the attacks, the longer each one lasts. These attacks are repeated with more or less regularity, and during the intervals the patient may feel perfectly well. In some cases the disease expends itself in a few weeks without treatment. In others it becomes chronic, the attacks occur with more and more irregularity, a secondary anemia is produced by the destruction of the red cells, and sclerotic changes take place in the viscera.

In the remittent type, the paroxysms occur with more regularity than in the intermittent, but the fever never entirely subsides. Owing to its greater prevalence during the late summer and fall, it has recently been grouped with some other irregular types under the head of æstivo-autumnal fever.

Intermittent fever is known as quotidian, tertian or quartan, according as the paroxysms occur daily or with one or two days intervening. There are also double types of each, in which the paroxysms occur with twice this frequency, but with the alternate paroxysms corresponding in time and severity.

In certain cases of intermittent fever, the attacks, instead of occurring at the same hour, occur a little earlier each day, or a little later each day, and are called *anticipating* or *retarding* accordingly. This feature is thought to be an indication of increasing or decreasing severity.

The Parasite of Malaria.

While each form of the fever has its characteristic variety of plasmodium, it will not be necessary, in order to make a diagnosis of malaria by the microscope, to become an expert in their differentiation. Having found the plasmodium in any one of its varieties, the clinical features of the disease will usually tell you which variety it is. It is well, however, to have in mind a general idea of the different forms.

A well-developed parasite of any variety consists of a mass of hyaline protoplasm which, in addition to a scarcely perceptible nucleus, contains dark brown granules, the granules in well-preserved blood being in more or less active motion, and the whole contained within the body of a red cell.

The protoplasm of the parasite presents active ameboid movements, and it is thought that the dancing motion of the pigment granules is due to this. The plasmodium is best seen in specimens taken an hour or two before the chill, though they may be seen in different stages of their growth as late as twenty-four hours after the paroxysms, if quinine has not been given, and sometimes even then. At times they will be found in great numbers, even appearing in the first field looked at; at others a search of an hour or more through several specimens must be made before you will be rewarded by the sight of one. In some of the irregular forms, and especially in the æstivo-autumnal type, the elaboration of the parasite takes place in certain of the internal organs, notably the spleen and bone marrow, and scarcely any of the well-developed organisms are to be found in the peripheral circulation. In these cases especially it is important to take the blood just before the paroxysm, to have the specimen well spread, and to make a patient search. Close observation of the maturing parasite in the common forms has shown that, as it ripens, the brown pigment granules gradually cease dancing and collect at the center of the corpuscle, which is now almost filled with the parasite, while fine, scarcely discernible lines, radiating from this point, divide the protoplasm of the parasite into segments like the petals of a flower. These segments are the *spores*, which a little later break apart and become free spheroidal bodies ready to attack new cells, enter them and devour their hemoglobin, the indigestible part of which is represented by the brown granules. Every time a group of parasites matures, and the spores are thrown out into the blood stream, the patient suffers a paroxysm. Just the reason for this is not known, but it has been suggested that some toxine is thrown off, together with the spores, when the parasite bursts.

The chief characteristics of the full grown parasites of different varieties are as follows: —

Tertian.	Quartan.	Æstivo-autumnal.
1 Size of a normal red cell.	1 Smaller.	1 Still smaller, often less than half the size of a red cell.
2 The red cell containing it expands and loses its color.	2 The red cell shrinks around it and assumes a deeper greenish-yellow hue.	2 Usually the same as in the quartan.
3 Ameboid movements very active.	3 Ameboid movements slower.	3 Still slower.
4 Granules fine and numerous.	4 Coarse and few.	4 Coarse and very few.
5 Segments 15 to 20 or more.	5 Segments usually 5 or 6.	5 Segments 15 to 20 or more.

At the beginning of the æstivo-autumnal type of the disease, only the early stages of the parasite are found in the peripheral circulation, and these are seen as small intracellular hyaline bodies containing one or two pigment granules. After the process has lasted a week or more, there appear in addition the large *crescentic and rounded bodies* which are characteristic of this type of the disease. These crescent bodies have caused much discussion and less is known of them than of any other form. The sum of our knowledge is that they are associated with the severe and irregular form of malaria known as *æstivo-autumnal,* that they do not appear until the second or third week, that they are a very resistant type with a longer cycle of development than the small forms, that their presence in the blood is often unassociated with fever, and the best observers have never seen them develop spores.

Certain features appear in malarial blood that has been withdrawn from the body for some time which are not found in the circulating blood, as evidenced by the fact that they are never seen in specimens fixed immediately after withdrawal. These are the *large extracellular bodies* and the *flagellate forms.*

The large extracellular body presents all the characteristics of those found in the cells, and is, in fact, one of these which has escaped from its enclosing cell. The event may sometimes be seen while examining blood taken just before the chill, and presents the appearance of a mass of soft jelly being slowly poured out of a shallow bowl. The flagellated forms occasionally seen appear fifteen to twenty minutes after the blood is withdrawn. The first thing noticed is an apparently causeless agitation of the corpuscles surrounding the pigmented body, then by close watching a faintly outlined, vigorously writhing prolongation from the parasite may flash into view for a second. There are several of these, but it is rare to see them all at once. They are usually clubbed and pigmented at the end, and sometimes may be seen to break off and float away in the plasma, shrinking into small, rounded bodies. This flagellated form is thought by some to be the extra corporeal form of the mosquito parasite.

Widal's Test for the Diagnosis of Typhoid Fever.

"This test is based upon the action on cultures of bacillus typhosus of bactericidal substances developed in the blood of subjects suffering from typhoid fever.

"When to a tube of a twenty-four hours' broth culture of bacillus typhosus is added one tenth as much blood serum from a patient suffering from typhoid fever and showing the typical reaction, the bacteria are rendered motionless and precipitated from the fluid in clumps. The reaction may be performed with a hanging drop preparation of the culture, to which, when a drop of dissolved blood is added from a platinum loop, the typical reaction is indicated by the rapid loss of motility of the bacilli and their clumping in characteristic masses.

"When Widal's test is properly performed, by adding one part of serum to ten of the culture a prompt reaction renders the diagnosis of typhoid fever extremely probable.

"When one part of serum is added to twenty of the culture a prompt reaction is almost certainly indicative of typhoid fever.

"On the other hand, a negative reaction is of little value as against typhoid fever.

"The partial reactions often secured with less diluted blood are unreliable.

"*Occurrence of Widal's Reaction.* — From the compilation of a large number of cases, the New York Health Board concludes that Widal's reaction is present in typhoid fever.

"From the fourth to seventh day in 70 per cent. of the cases.

"From the eighth to fourteenth day in 80 per cent. of the cases.

"During the third and fourth weeks in 90 per cent. of the cases.

"It is absent throughout in 5 to 10 per cent. of the cases.

"Widal's reaction persists in the blood for months, or even years, but after three or four months is usually feeble.

"*Method of Procedure.* — It is usually required to make the test from specimens of dried blood, which do not permit of exact dilution.

"Sufficiently accurate results may be obtained by dissolving the clot in an equal quantity of distilled water, and mixing one part of the solution with nine parts of the culture by means of a capillary tube. The mixing pipette of the hemocytometer is graduated in ten divisions, and may be used for this purpose, the mixed fluids being carefully expelled on a cover-glass for the hanging drop preparation.

"With a sharp reaction the loss of motility and clumping is complete by the time the preparation is ready for examination. A distinct reaction may not be complete till after five to fifteen minutes have elapsed. In feeble reactions the clumping is not complete till after thirty minutes, and some bacilli are apt to remain permanently motile. Such reactions are unreliable evidences of typhoid fever.

"A rough demonstration of Widal's reaction may be made by dissolving the clot in distilled water, and preparing the hanging drop by means of a platinum loop.

"The culture to be used should be a twenty-four-hour broth culture of medium virulence, actively motile, and grown in the thermostat." —*Ewing-Clinical Diagnosis.*

APPENDIX.

The Estimation of Hemoglobin by Means of the Specific Gravity of the Blood.

Hammerschlag's method, so called, which is a modification of Roy's, according to a principle first announced by Fano, is the one in general use. The outfit needed consists of (1) an urinometer graduated from 1.025 to 1.070, (2) the cylindrical vessel which accompanies it, (3) a bottle of benzol, (4) a bottle of chloroform, (5) a bottle containing a mixture of the two, (6) a medicine dropper, (7) a glass rod, (8) the white corpuscle mixer from your Thoma-Zeiss apparatus, or a plain pipette of about the same bore, with a rubber tube attached.

The principle involved is this: Chloroform is heavier than blood, hence the drop of blood will float upon it; benzol is lighter than blood, hence the drop will sink in it. A mixture in which a drop of blood will remain suspended must be of the same specific gravity as the blood itself. According to Hammerschlag, the range of specific gravity of normal human blood in the male is 1.057 to 1.066, that of the female 1.054 to 1.061. The variation in the specific gravity has been found to follow pretty closely that of the hemoglobin of the cells, though, of course, no account will appear by this method of that which may be floating in the plasma, which has a specific gravity of only 1.030. If a low hemoglobin is suspected, start with a mixture of chloroform and benzol of about 1.040 sp. gr. Having made the puncture in the usual way, draw up two large drops of blood into the pipette, blow out a little from the tube and wipe it away, then blow part of the remainder into the mixture, leaving some in the tube.

These precautions are taken in order to exclude the possibility of air being in the drop and making it lighter. If the drop sinks, add chloroform; if it rises, add benzol until the drop remains suspended in the mixture. Then take the specific gravity of the mixture.

The additions should be made a few drops at a time and the mixture stirred with a glass rod. The benzol being so much lighter than chloroform, it is difficult to get it to the bottom of the cylinder, and it may be necessary to close the mouth of the vessel with the palm of the hand, and carefully invert it.

The mixture may be filtered, and used for subsequent examinations. The pipette must of course be cleaned and dried in the usual way.

The following table of Hammerschlag gives the specific gravity corresponding to different percentages of hemoglobin as ascertained by the Fleischl apparatus: —

Specific Gravity.	Hemoglobin (Fleischl).
1.033 to 1.035	25 to 30 per cent.
1.035 to 1.038	30 to 35 „
1.038 to 1.040	35 to 40 „
1.040 to 1.045	40 to 45 „
1.045 to 1.048	45 to 55 „
1.048 to 1.050	55 to 65 „
1.050 to 1.053	65 to 70 „
1.053 to 1.055	70 to 75 „
1.055 to 1.057	75 to 85 „
1.057 to 1.060	85 to 95 „

Oliver's Hemaglobinometer.

This instrument owes its perfection to the tintometer of James Lovibond, an English chemist, who has spent a lifetime in the study of colors and coloring matters, and who has reduced colorimetry to something approaching an exact science. He found that every colored substance, when progressively varied in concentration or in strata thickness, furnishes a color curve peculiar to itself. The impossibility, therefore, of making a glass wedge like that of the Fleischl instrument, which shall exactly correspond in color in successive portions, to progressively varying strengths of hemoglobin solution, becomes at once apparent. By means of the tintometer, Oliver was enabled to make solutions of carmine varying, not according to a regular progression of dilution, but in just such proportions as would correspond to the specific color curve of hemoglobin. In addition to this distinct advantage over the Fleischl instrument, there are two others which are found in that of Oliver: First, by presenting the standard as a series of definite gradations, the comparison of the blood solution with it does not present the difficulty that obtains in the Fleischl instrument, which shows as much as 20 degs. at once. Secondly, by using reflected light, the color of a solution is fully double that of the same strength seen by transmitted light, making a comparison of the colors easier. It is well known that the error in reading the Fleischl instrument is much greater toward the lower end than toward the upper end of the scale, owing to the extreme pallor of weak solutions of hemoglobin as seen by transmitted light, — so that usually two or three times the ordinary amount of blood is taken in order to increase the depth of color. With the reflected light, 5 c. mm. gives as deep a color as 10 c. mm. would in the Fleischl apparatus.

Oliver's apparatus consists of (1) an automatic blood measurer or capillary pipette, (2) the mixing pipette, (3) a blood cell and cover-glass, (4) the sets of standard gradations, (5) the riders, (6) the camera tube. In addition are needed a candle, a needle and darning cotton for cleaning and drying the capillary pipette and a pricker for making the puncture.

1. Instead of being a fragile thing, like that which accompanies Fleischl's instrument, the capillary pipette is of thick glass, with a capacity of 5 c. mm., and the end to be presented to the blood is polished so that any traces of blood on the outside can be easily wiped away with the finger. The bore is large enough to permit of thorough cleaning and drying by means of the needle and darning cotton.

2. The mixing pipette has a rubber nozzle fitting over the polished end of the capillary tube, and when charged with water before it is attached, a thorough rinsing out of the blood in the tube is assured.

3. The blood cell is large, yielding a solution of not less than 1 per cent. when filled to the brim.

4. The graded standards are circular disks set in two slabs, 6 in each, each disk representing 10 per cent. of the scale from 10 to 120, both inclusive.

5. The riders are colored pieces of glass to be laid upon the disks providing for the degrees between the tens. For physiological examinations, where readings are desired as close as 1 per cent., a set is furnished consisting of 9 riders set in three sides. For clinical work, a single rider is provided capable of giving readings to within 2½ per cent.

6. The camera tube is in two forms, one a metal tube blackened on the inside, capable of being raised and lowered by means of an arm and thumb screw by which it is attached to a stand, and provided with a flange on the top, to cut off the light of the candle from the eye of the examiner. Into this flange is set a piece of green glass. By looking at the candle through this the color sensitiveness of the eye can be quickly restored if blunted by long or repeated examinations. The lower end of the tube is closed except for two apertures of 5 mm. diameter, so that but a small portion of each of the blood solution and the color disk are seen at once, thus making the contrast more sharp. Another form of the camera for bedside work is a collapsible tube, which occupies less space and can be packed in a case with the other parts of the instrument. The small-sized wax candle known as a Christmas candle has been found to give the most suitable intensity of light. It should be placed so that the flame is 3 or 4 ins. above the level of the cells and sheds an equal light upon each, and should be at such a distance from them as to give the best illumination.

Method of Use.

The capillary tube, cleaned and dried as stated above, is filled in the same way as the Fleischl: the outside blood having been wiped away with the finger, the mixing pipette previously charged with water is attached by its rubber nozzle to the polished end, and the blood washed out into the blood cell, which is then carefully filled to the brim. By catching with the eye the reflection from the surface of the liquid, this can be quickly and accurately done. The handle of the capillary tube is then used to thoroughly mix the contents of the cell, and the cover-glass is laid on it, a small bubble forming between the cover-glass and the surface of the liquid showing that the cell has not been overfilled. The cell is now brought near the colored disks, and a glance will show which one of the 10 deg. gradations it most nearly approximates in color. If you have the full set of riders, select that colored disk which is next lighter in color than the solution, and, bringing the camera tube into use, place the riders in succession upon the color disk until that one is found which corresponds exactly to the color of the blood solution. If the single rider, representing 5 degs., is the only one at hand, and the blood solution is seen to be, for example, between 50 and 60, the rider is placed upon the 50 disk, making it 55; if then the solution is darker than this, it may be called 57½, if lighter, 52½.

Another set of disks and rider are also made for use with ordinary daylight.

Oliver's Hemocytometer.

The principle involved: —

(A) When a candle flame is viewed through a glass tube containing water, a transverse bright illumination is seen consisting of closely packed minute images of the flame produced by the longitudinal fibrillations of the glass, each fibrillation acting as a lens.

(B) When some fixing fluid like Hayem's is added to the blood, the mixture presents a certain degree of opacity, according to the amount of the blood or of the fixing fluid.

(C) The opacity completely shuts out the line, until on diluting further a definite point is reached, when it can just be detected as a delicate streak of light across the tube, the dawn as it were of the bright line of the congeries of minute images of the flame, seen when the opacity is absent, or the dilution is carried still further.

(D) Repeated observations have shown that the development of this delicate line by dilution of the fluid selected is a very sensitive indicator of the percentage of the cells, shown, for example, by the measure required to bring the line into view always being in proportion to the different quantities of blood taken, and, therefore, of the number of cells present.

The apparatus includes: (1) A four-sided glass tube, 15 mm. in one diameter and 5 mm. in the other, having about 12 cm. of its length graduated by twos up to 120. (2) A capillary pipette like that of the hemoglobinometer, except that it has a capacity of 10 cm. (3) A mixing pipette with a rubber nozzle. (4) A bottle of Hayem's solution. (5) A candle.

Method of Use.

Fill the capillary pipette, wipe away the excess of blood, attach the mixer previously filled with Hayem's solution, and wash into the graduated tube. Withdrawing now into a room lighted only by a candle, fill the tube rapidly up to a point which you estimate to be somewhat below the number of red cells, remembering that each gradation represents 100,000 corpuscles. Standing now about ten feet away from the candle, hold the tube close to the eye, with its long diameter between the eye and the candle, shielding the eye from the direct rays by means of the thumb and fingers. Continue the dilution, a few drops at a time, at each addition closing the mouth of the tube with the thumb, and inverting once or twice to insure thorough mixing, and taking care to scrape the thumb on the edge of the tube each time it is removed in order that no fluid may be lost.

As the dilution progresses, the first suspicion of the line is seen by rotating the tube upon its long axis so that you look through it diagonally, and it extends across the entire tube with the addition of a few more drops. Now read off the percentage. The subdivisions of the scale are wide enough so that readings can easily be made as close as half a division, *i. e.*, to within 50,000 corpuscles.

The Hematocrit.

A rapid approximate determination of the relative percentage of corpuscles may be made by Blix's method — Hematocrit. The blood is mixed with a definite amount of 2½ per cent. potassium bichromate and centrifugalized. (See Fig. 4, page 8.) The corpuscles rapidly accumulate at the bottom in an almost solid mass, and their collective volume can be directly read off. The estimation can be made with a small quantity of blood, and is therefore capable of being used for clinical purposes. The average percentage of corpuscles in human blood, as obtained by these several methods, is about 48, or very nearly one half of the entire amount of blood. Hedin obtained in himself an average percentage total corpuscular column of 51, the greatest differences in his own blood being 54.4 and 48 per cent.; but the average for a large number of adult males was 48 and of females 43.3 per cent. In children of six to thirteen years the amount was 45 per cent. — *Schäfer's Physiology.*

Explanation of Plates III., IV., V., VI.

Plates III., IV., V., VI. (Magnification, 664. Zeiss Apochromatic $\frac{1}{12}$ oil immersion, ocular No. 8.)

Plates III., IV., VI., stained with Ehrlich's tri-acid stain.

Plate V., stained with eosin and methylene blue.

Plate III., Fig. 1: Normal blood of adult. Figs. 2, 3, 4, 5, 6: Different forms of leucocytosis. Fig. 1: (*a*) normal red cell. (*b*) a red cell, some of the contents of which are seen extruded. (*c*) polynuclear neutrophile. (*d*) eosinophile. (*e*) lymphocyte. (*f*) blood plates.

Fig. 2 : (*a*) polynuclear neutrophile. (*b*) eosinophile. (*c*) lymphocyte. (*d*) blood plates.

Fig. 3 : (*a*) polynuclear neutrophile. (*b*) lymphocyte. (*c*) myelocyte. (*d*) blood plates. (*e*) breaking red cell with extruded contents.

Fig. 4 : (*a*) polynuclear neutrophile. (*b*) eosinophile. (*c*) lymphocyte. (*d*) extruded contents of red cell. (*e*) myelocyte. (*f*) large lymphocyte.

Fig. 5 : (*a*) polynuclear neutrophile. (*b*) eosinophile. (*c*) lymphocyte. (*d*) blood plates.

Fig. 6 : (*a*) polynuclear neutrophile. (*b*) lymphocyte. (*c*) uncommon form of basophile as yet unnamed.

Plate IV. : Fig. 1 : Myelogenous leukemia. (*a*) polynuclear neutrophile. (*b*) eosinophile. (*c*) lymphocyte. (*d*) myelocyte. (*e*) mononuclear eosinophile. (*f*) uncommon form of basophile as in Plate I., Fig. 6, letter *c*. (*g*) large lymphocyte with small nucleus. (*h*) nucleated red cell of normoblast type. (*i*) blood plate. (*k*) detritus from broken red cells. (*l*) megaloblastic form of nucleated red cell.

Fig. 2 : Chlorosis, mild form. (*a*) polynuclear neutrophile. (*b*) eosinophile. (*c*) lymphocyte. (*d*) chlorotic red cell. (*e*) poikilocyte. (*f*) polychromatic red cell. (*g*) large lymphocyte.

Fig. 3 : Grave anemia. (*a*) polynuclear neutrophile. (*b*) eosinophile. (*c* and *d*) lymphocytes. (*e*) poikilocyte. (*f*) microcyte. (*g*) polychromatic red cell. (*h*) normoblast.

Fig. 4 : Pernicious anemia. (*a*) polynuclear neutrophile. (*b*) lymphocyte. (*c*) normal red cell. (*d*) poikilocyte. (*e*) microcyte. (*f*) megaloblast. (*g*) normoblast. (*h*) polychromatic red cell. (*i*) separated nucleus of red cell much like a lymphocyte. (*k*) crenated red cell.

Fig. 5 : Pernicious anemia. (*a*) polynuclear neutrophile. (*b*) lymphocyte. (*c*) myelocyte not often found in this condition. (*d*) normal red cell. (*e*) poikilocyte. (*f*) microcyte. (*g*) megalocyte. (*i*) polychromatic megaloblast. (*k*) megaloblast. (*l*) vacuolated red cell.

Fig. 6 : Anemia pseudo-leukemia infantum. (*a*) polynuclear neutrophile. (*b*) eosinophile. (*c*) lymphocyte. (*d*) large lymphocyte. (*e*) polychromatic microblast. (*f*) normal red cell. (*g*) uncommon form of basophile. (*i*) myelocyte. (*k*) poikilocyte. (*l*) microcyte. (*m*) red cell with extruded contents. (*n*) polychromatic normoblast. (*o*) polychromatic red cell. (*p*) megaloblast.

Plate V., Fig. 1 : Normal blood. (*a*) polynuclear neutrophile (granules not shown). (*b*) eosinophile. (*c*) lymphocyte. (*d*) normal red cell. (*e*) red cell with extruded contents.

Fig. 2 : Lymphatic leukemia. (*a*) polynuclear neutrophile (with diminished granulation). (*b*) small lymphocyte. (*c*) large lymphocyte. (*d*) transitional cell, *i. e.*, large basophile with indented nucleus.

Fig. 3: (*a*) polynuclear neutrophile (granules not shown). (*b*) eosinophile. (*c*) lymphocyte. (*d*) blood plates. (*e*) mast cell.

Fig. 4: Grave anemia in a child. (*a*) polynuclear neutrophile (with diminished granulation). (*b*) small lymphocyte. (*c*) large lymphocyte. (*d*) transitional cell. (*e*) normal red cell. (*f*) poikilocyte. (*g*) microcyte. (*h*) nucleated red cell. (*k*) polychromatic red cell.

Fig. 5: Malarial blood. (*a*) polynuclear neutrophile (granules not shown). (*b*) eosinophile. (*c*) lymphocyte. (*d*) blood plates. (*e*) red cell with extruding contents. (*f*) plasmodium malariæ in red cell.

Fig. 6: (*a*) Spirillæ recurrens. (*b*) lymphocyte.

Plate VI., Fig. 1: Blood of embryo of pig. (*a*) metrocyte (first generation). (*b*) metrocyte (first generation) with divided nucleus. (*c*) smaller metrocytes, after division. (*d*) metrocyte (second generation). (*e*) nucleated red cell from metrocyte of second generation. (*f*) macrocyte (non-nucleated remains of metrocyte of second generation).

Fig. 2: Blood of human fœtus (two and one half months). (*a*) metrocyte (second generation). (*b*) small metrocyte. (*c*) polychromatic nucleated red cell. (*d*) normal red cell. (*e*) macrocyte. (*f*) polychromatic red cell. (*g*) broken red cell with extruding contents. (*h*) lymphocyte. (*i*) extruded nucleus of red cell.

Fig. 3: Blood from liver of same foetus. (*a*) metrocyte (second generation). (*b*) normal red cell. (*c*) macrocyte. (*d*) nucleated red cell. (*e*) nucleated red cell, polychromatic. (*f*) large nucleated red cell or megaloblast.

Fig. 4: Blood of fœtus of four and one half months. (*a*) polynuclear neutrophile with feeble granulation. (*b*) myelocyte. (*c*) eosinophile. (*d*) lymphocyte. (*e*) red cell with extruding nucleus. (*f*) extruded nucleus of red cell. (*g*) normal red cell. (*h*) polychromatic red cell. (*i*) nucleated red cell. (*k*) small nucleated red cell or microblast.

Fig. 5: Normal bone marrow of adult. (*a*) myelocyte. (*b*) eosinophilic myelocyte. (*c*) small lymphocyte. (*d*) large lymphocyte. (*e*) giant cell. (*f*) normal red cell. (*g*) nucleated red cell. (*h*) polychromatic nucleated red cell. (*i*) red cell with extruded contents. (*k*) polychromatic megaloblast.

Fig. 6: Bone marrow in pernicious anemia. (*a*) myelocyte. (*b*) eosinophilic myelocyte. (*c*) small lymphocyte. (*d*) large lymphocyte. (*e*) macrocyte. (*f*) megaloblast. (*g*) nucleated red cell of normoblast type, *i. e.*, of same size as normal red cell.

Iron Therapy In General— Hemaboloids In Particular.

"*The treatment of Chlorosis and Anemia* is *not simply iron,* but the *right kind* of iron, together with suitable dietetic and hygienic measures."

The iron in Hemaboloids is in organic combination with the readily absorbable nucleo-albumens of the vegetable kingdom, the sole natural iron-contributing constituents of our daily dietary.

"*While administering iron,* we should also see that our anemic or chlorotic patient gets enough to eat."

Why not administer an absorbable chalybeate and a reconstituent food at one and the same time? Hemaboloids, in addition to its ferruginous function, enhances nutrition by virtue of the general tissue reconstructives in its composition.

"*The plant has an extraordinary power* of absorbing mineral matter and making it take part in vital functions."

The vegetable nucleo-albumens take up the iron from the soil and convert it into an absorbable form. Hemaboloids is rich in these unaltered iron-bearing nucleo-albumens.

"*No matter how fine* your laboratory product of metallic iron may be, it is immeasurably harsh in comparison with organic food-iron ; carpet tacks are as assimilable as the metallic salts."

The iron in Hemaboloids is essentially a "food-iron," — bland, absorbable, and immediately available as a hematinic.

HEMABOLOIDS—Its Why and Wherefore.

Iron is a constant constituent of normal blood.

It is normally contributed to the hemoglobin through the food.

The foods most rich in iron are of a vegetable nature.

The iron in the vegetable foodstuffs exists in true organic combination.

It is combined with complex proteid bodies, known as nucleo-albumens.

These nucleo-albumens are the iron-contributing factors of our daily dietary.

Hemaboloids is rich in unaltered, vegetable nucleo-albumens.

The iron in Hemaboloids is, therefore, of true organic source and nature.

Hemaboloids supplies iron as Nature supplies it.

Inorganic salts of iron are harsh, irritant, and unpalatable.

Hemaboloids iron is bland, devoid of harshness, and is palatable.

Metallic iron is absorbed but very little, if at all.

Hemaboloids iron (natural vegetable iron) is absorbed promptly and completely.

Inorganic iron preparations corrode the teeth and constipate.

Hemaboloids is non-corrosive and non-constipating.

Hemaboloids also possesses tissue-forming properties.

It contains Bone-Marrow Extract, Beef Peptone, and Nuclein.

It is, therefore, a general tissue reconstructive as well as a blood enricher.

The dose of Hemaboloids is one to two tablespoonfuls three to six times a day.

HEMABOLOIDS—Arseniated

With Strychnia.

While it is a matter of every-day professional observation that absorbable organic ferruginous preparations produce prompt improvement in uncomplicated Anemia and Chlorosis, there are unquestionably many depreciated blood states beyond the remedial power of any form of iron. For instance, the severer forms of Chlorosis, Secondary Anemias symptomatic of Tuberculosis, Malaria, Gout, Rheumatism, etc., and essential Pernicious Anemia. Such conditions need something more than iron, or even iron reinforced by vitalizing tissue nutritives, as in Hemaboloids. Arsenic, because of its tonic alterative effect, and Strychnia, on account of its power of toning up the heart and nervous system, are the agents usually resorted to and almost always with success. According to Mitchell Bruce, arsenic combines with the blood corpuscles as an albuminate, and although rapidly excreted produces a wholesome increase of the metabolism or vital activity of all the organs.

Hemaboloids-Arseniated with Strychnia contains both of these medicinal agents in readily absorbable organic condition, each tablespoonful representing the equivalent of $^{1}/_{40}$ grain arsenious acid and $^{1}/_{80}$ grain Strychnia.

These drugs serve to powerfully augment the hemoglobin building action of the vegetable iron in Hemaboloids and the tissue-constructing power of its alimentary constituents; Hemaboloids-Arseniated with Strychnia is also indicated in Chorea, Chronic Malarial Cachexiae, Anemia complicated by chronic skin affections (psoriasis, scaly eczema, etc.), and whenever the well-known alterative action of arsenic, the nerve and heart toning effects of Strychnia, and the blood-enriching properties of Hemaboloids are needed.

THE PALISADE MANUFACTURING COMPANY,
YONKERS, N. Y.

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First Word.

REALIZING the distinctly scientific trend of modern medical progress and the ever-increasing necessity for exactitude and precision in "matters diagnostic," the makers of HEMABOLOIDS are confident that the progressive members of the medical profession will welcome and appreciate a series of condensed but comprehensive text-books, describing succinctly all that is latest and best of the modern means and methods of diagnosis, including the most simple, practical, and direct technique.

This little volume on the Clinical Examination of the Blood is the first of the series; it will be followed after a reasonable interval by a similar compact treatise on Diagnostic Bacteriology, and subsequently by a working guide to the Clinical Examination of the Stomach Contents for purposes of diagnosis. We hand you this book, Doctor, with the sincere hope that it may be of real and practical service to you in your daily struggle with disease and death.

Sincerely yours,

THE PALISADE MANUFACTURING CO.,
Yonkers, N. Y.

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Technique of Blood Analysis.

Making the Puncture.

The finger tip and the lobe of the ear are the usual points of attack. The latter is to be preferred because it is less painful, and the patient is spared the sight of flowing blood. One corner of a towel is moistened in plain water, and the skin over the site of the intended puncture is cleaned by rubbing briskly, first with the moist and then with the dry part. Pinching the free edge of the lobe between the thumb and forefinger, with the corresponding fingers of the free hand firmly holding a Hagedorn, or bayonet-pointed needle of medium size, the puncture is made with a quick, springy stroke. A little practice will make one an adept and the sting of the needle will scarcely be felt. Even young children and weak, nervous patients, who utter a howl of protest at the suggestion of the first puncture, smilingly submit to future examinations. The flow of blood, which begins upon the removal of the pinching fingers, can be accelerated by wiping away the first ooze with the moist, followed by the dry part of the towel. Only the most delicate pressure should be used in urging the flow. If this is not successful, make another and deeper puncture, otherwise the blood will be diluted with lymph.

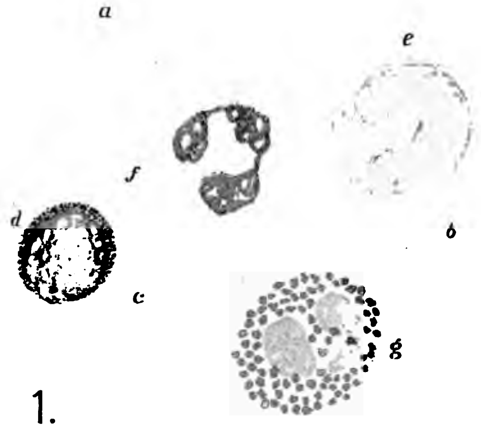
The usual procedures in the analysis of blood include: —

1. The estimation of hemoglobin.
2. The estimation of iron.
3. The enumeration of red and white cells.
4. The examination of dry specimens stained in various ways.
5. The examination of fresh specimens.

The Method of Estimating the Percentage of Hemoglobin.

Fleischl's Hemometer (Hemoglobinometer).

The best instrument in general use for this purpose is known as v. Fleischl's Hemometer. (See Fig. 3, page 7.) It consists of (1) a cylindrical cell for holding the prepared blood, (2) a graduated wedge-shaped piece of colored glass with



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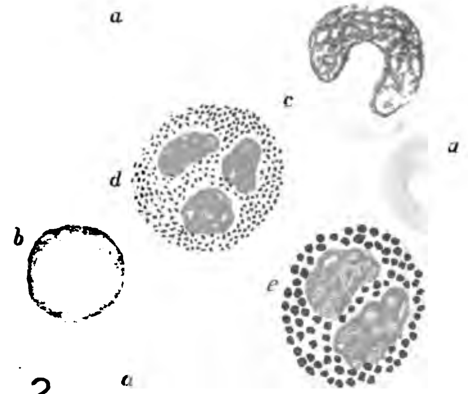

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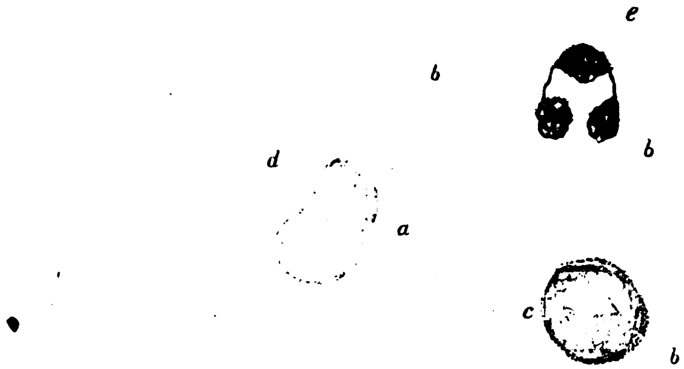

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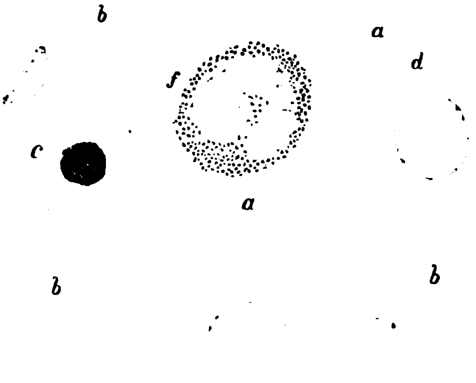

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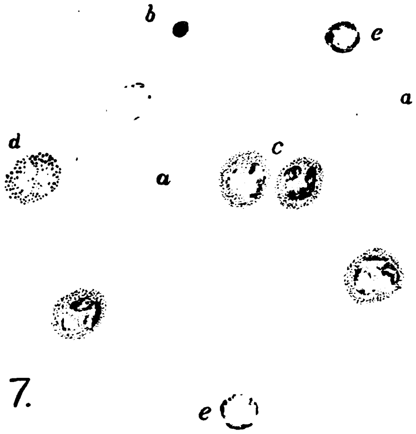


7.

FOR EXPLANATION SEE BACK OF THIS PLATE.

PLATE II

Fig. 5. Primary Pernicious Anemia.

a.	Megalocyte.
b.	Microcytes.
c and d.	Microcytes deficient in Hemoglobin.
e.	Megaloblasts.
f.	Lymphocyte.
g.	Large Mononuclear Leucocyte.

Fig. 6. Primary Pernicious Anemia.

a.	Megaloblast.	Nucleus in "Thread Stage."
b.	Megaloblasts.	Nucleus in "Aster Stage."
c.	Megaloblast.	Nucleus in "Resting Stage."
d.	Megaloblast.	Extrusion of Nucleus.
e.	Microblast.	
f.	Poikilocytes.	
g.	Normal sized red Cell.	
h.	Microcyte.	

Fig. 8. Von Jaksch's Anemia.

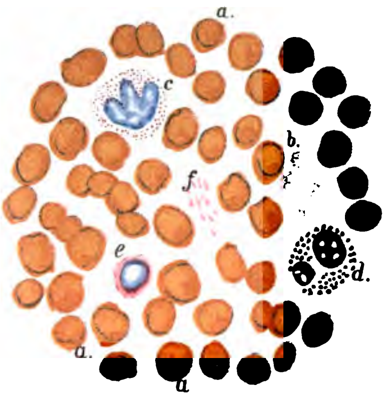
a.	Anemic Red Cells.
b.	Normoblasts.
c.	Polynuclear Leucocytes.
d.	Myelocyte.
e.	Lymphocytes.

Fig. 9. Secondary Pernicious Anemia. Cancer of the Stomach.

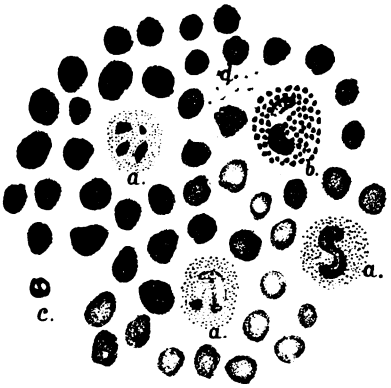
a.	Microcytes.
b.	Polynuclear Leucocytes.
c.	Megalocyte.

Fig. 10. Secondary Pernicious Anemia. Advanced Syphilis.

a.	Red Cells deficient in Hemoglobin.
b.	Red Cells with excess of Hemoglobin.
c.	Normoblast.
d.	Mononuclear Leucocytes.
e.	Polynuclear Leucocytes.



NORMAL BLOOD OF ADULT, SEE PAGE 43



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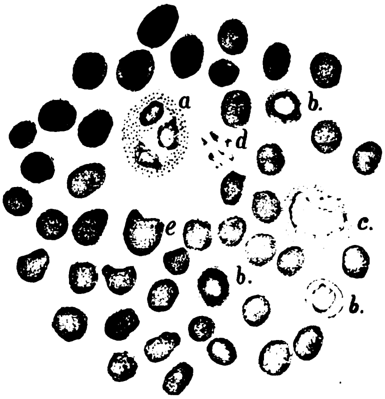

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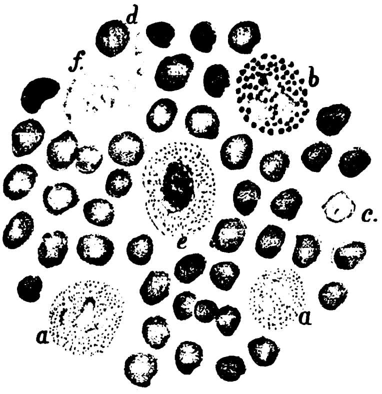
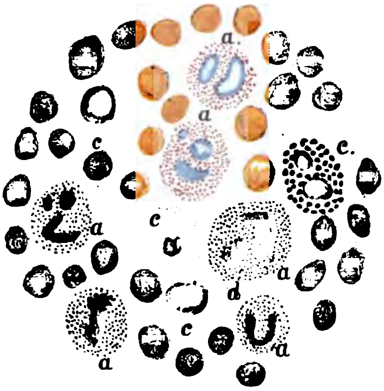
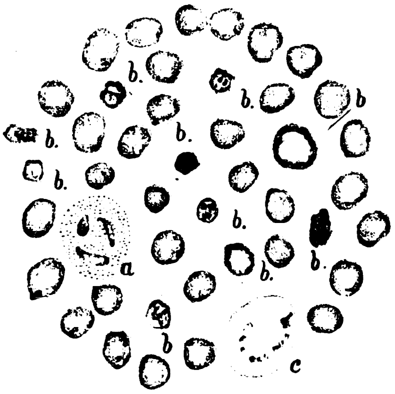


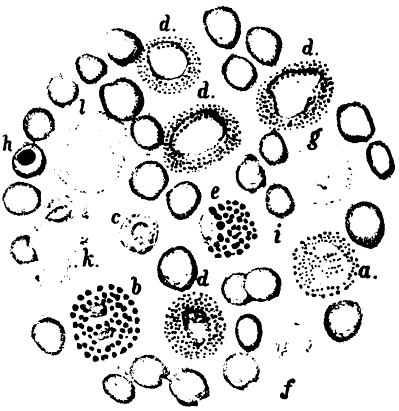
LEUCOCYTOSIS, SEE PAGE 44



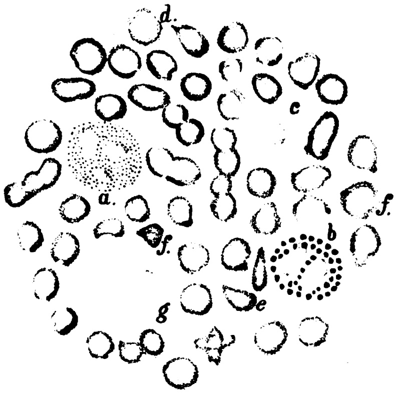
LEUCOCYTOSIS, SEE PAGE 44



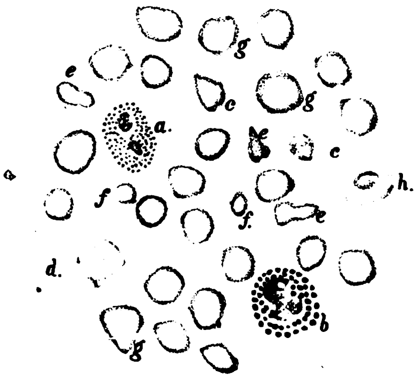
LEUCOCYTOSIS, SEE PAGE 44



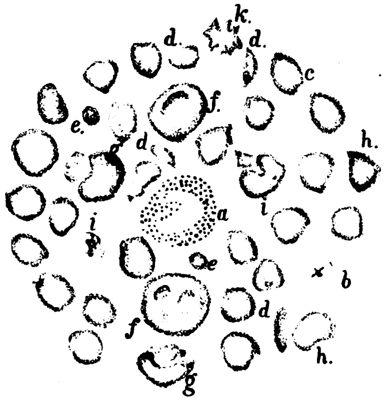
MYELOGENOUS LEUKEMIA, SEE PAGE 44.



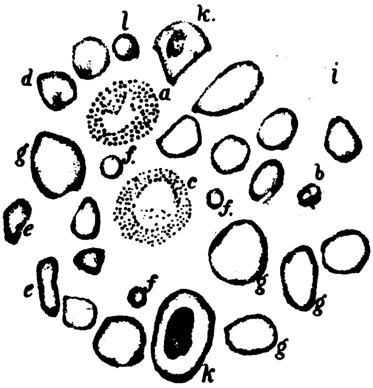
CHLOROSIS MILD, SEE PAGE 44.



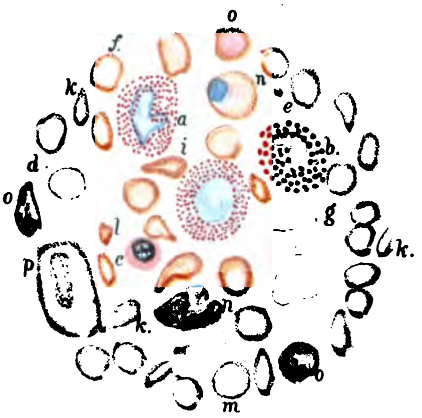
GRAVE ANEMIA, SEE PAGE 44.



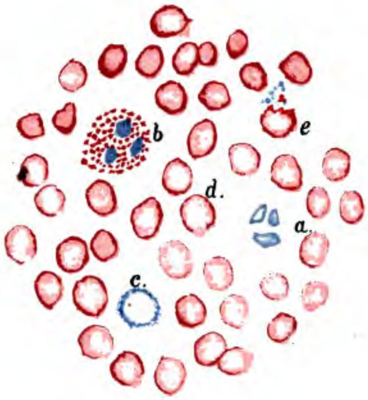
PERNICIOUS ANEMIA, SEE PAGE 44.



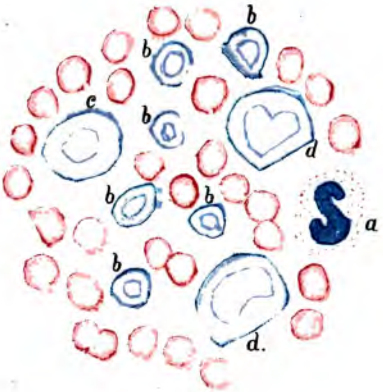
PERNICIOUS ANEMIA, SEE PAGE 44.



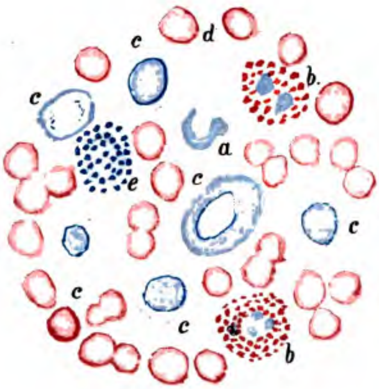
ANEMIA PSEUDO-LUKEMIA INFANTUM. SEE PAGE 44.



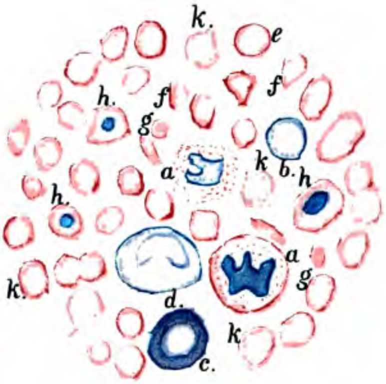
NORMAL BLOOD, SEE PAGE 44.



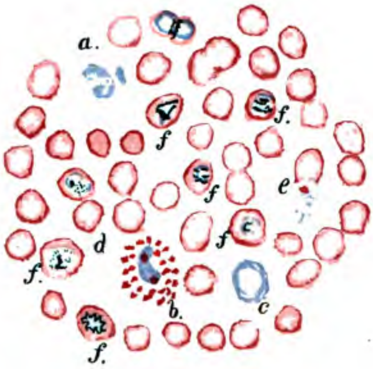
LYMPHATIC LEUKEMIA, SEE PAGE 44.



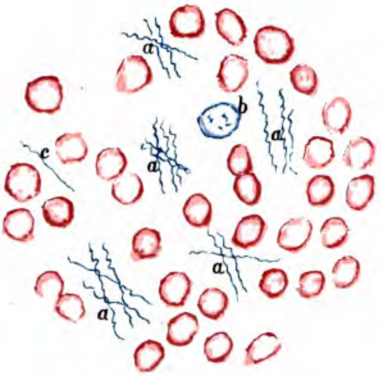
AST-CELL AND EOSINOPHILE CELLS IN LEUKEMIA, SEE PAGE 45.



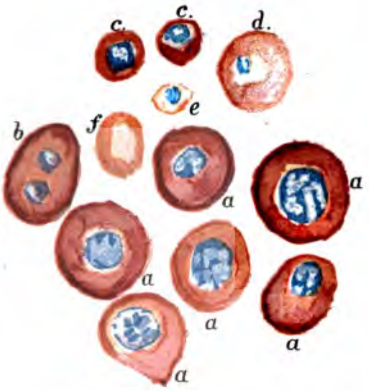
GRAVE ANEMIA IN CHILD, SEE PAGE 45.



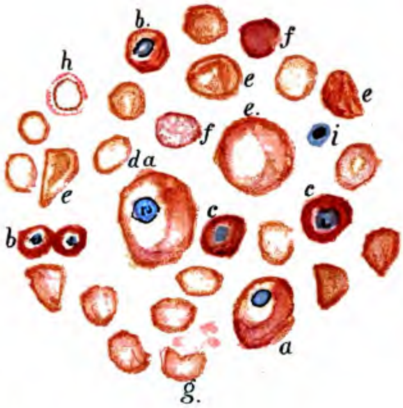
MALARIAL BLOOD, SEE PAGE 45.



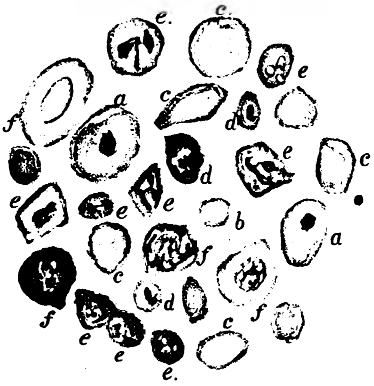
BLOOD OF RECURRENT FEVER, SEE PAGE 45.



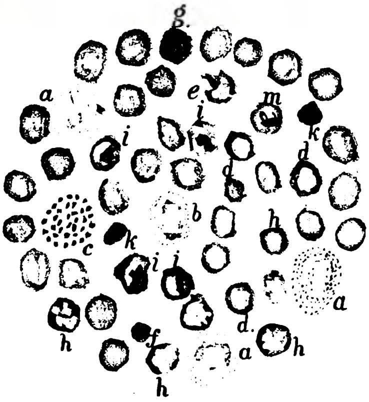
BLOOD OF EMBRYO OF PIG, SEE PAGE 45.



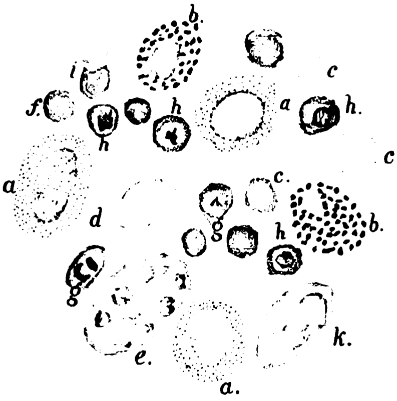
BLOOD OF HUMAN FOETUS, 2½ MONTHS, SEE PAGE 45.



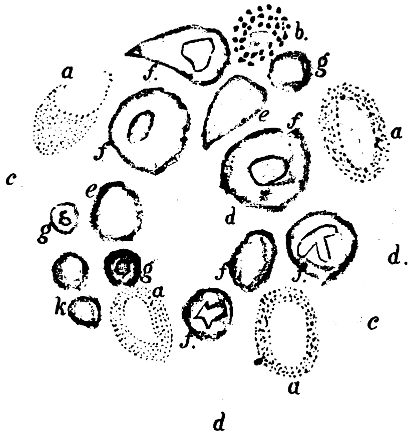
BLOOD FROM LIVER OF SAME FOETUS, SEE PAGE 45.



BLOOD OF FOETUS, 4½ MONTHS, SEE PAGE 45.



NORMAL BONE MARROW OF ADULT, SEE PAGE 45.



BONE MARROW IN PERNICIOUS ANEMIA, SEE PAGE 45.

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